APPENDIX C

Preliminary Screening-Level Human Health Risk Evaluation for Fuel Spill-1 Surface Water and Treatment System Data

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Tables

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ACRONYMS AND ABBREVIATIONS

AFCEE	U.S. Air Force Center for Environmental Excellence
DEP	Massachusetts Department of Environmental Protection
EDB	ethylene dibromide
EPA	U.S. Environmental Protection Agency
FS-1	Fuel Spill-1
HBC	hazard-based concentration
HQ	hazard quotient
IRIS	Integrated Risk Information System
RBC	risk-based concentration

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1.0 INTRODUCTION

A screening-level human health risk evaluation was conducted to examine the potential for imminent human health risks from exposure to chemical contaminants detected in surface water samples collected as part of the Quashnet River and bogs pilot test monitoring program for the Fuel Spill-1 (FS-1) plume. Samples were collected from 14 locations in the Quashnet River. Samples were also collected from the effluent port (36PLT01003) of the treatment system. All samples were collected May 2001 through April 2002 and were analyzed for metals, ethylene dibromide (EDB), and physicochemical parameters (treatment plant effluent only). Because chemicals (including EDB and metals) were detected in surface water, it is important to examine the potential for adverse risks to human health.

1.1 TECHNICAL APPROACH

Human health is evaluated in terms of imminent risk, that is, an excess individual cancer risk of $1x10^{-3}$ for carcinogenic compounds and a hazard quotient (HQ) of 10 for noncarcinogenic compounds. The approach used is consistent with protocols established by the U.S. Environmental Protection Agency (EPA) and exposure assumptions developed by the U.S. Air Force Center for Environmental Excellence (AFCEE), the EPA, and the Massachusetts Department of Environmental Protection (DEP) specifically for the Quashnet and Coonamessett bogs. Current toxicity data were obtained from the EPA Integrated Risk Information System (IRIS). Risk-based concentrations (RBCs) and hazard-based concentrations (HBCs) were developed for humans exposed to surface water. RBCs and HBCs were calculated for three receptor scenarios (waders, cranberry bog workers, and fish consumers).

The risk equations below evaluate exposure from dermal contact with surface water, incidental ingestion of surface water, and the consumption of fish from surface water bodies. Exposure factors and chemical-specific parameters used in the equations are provided in Tables C-1 and C-2. The following equations were used to calculate the various risk scenarios (e.g., cranberry workers) exposure concentration benchmarks.

$$RBC_{sw} = \frac{\text{target risk} \cdot BW \cdot AT_c}{CF_1 \cdot EF \cdot ED \cdot \left[SF_{ingest} \cdot IR_{sw} + CF_2 \cdot SF_{dermal} \cdot EV \cdot SA_w \cdot 2K_p \sqrt{\frac{6\tau \cdot t_{event}}{\pi}} + SF_{inhal} \cdot VF \cdot IR_h \cdot ET \right]}$$

(for waders, organic compounds)

$$RBC_{sw} = \frac{\text{target risk} \cdot BW \cdot AT_c}{CF_1 \cdot EF \cdot ED \cdot \left[SF_{ingest} \cdot IR_{sw} + CF_2 \cdot SF_{dermal} \cdot EV \cdot SA_w \cdot K_p \frac{t_{event}}{1+B} + 2 \cdot \tau \left(\frac{1+3B+3B^2}{(1+B)^2} \right) + SF_{inhal} \cdot VF \cdot IR_h \cdot ET \right]}$$

(for cranberry workers, organic compounds)

$$RBC_{sw} = \frac{\text{target risk} \cdot BW \cdot AT_c}{SF_{ingest} \cdot BAF \cdot IR_f \cdot FI \cdot CF_3 \cdot EF \cdot ED \cdot CF_1}$$

(for fish eaters)

$$HBC_{sw} = \frac{\text{target HQ} \cdot BW \cdot AT_n}{CF_1 \cdot EF \cdot ED \cdot \left(\frac{IR_{sw}}{RfD_{ingest}} + \frac{CF_2 \cdot EV \cdot SA_w \cdot 2K_p \sqrt{\frac{6\tau \cdot t_{event}}{\pi}}}{RfD_{dermal}} + \frac{VF \cdot IR_h \cdot ET}{RfD_{inhal}} \right)}$$

(for waders, organic compounds)

$$HBC_{sw} = \frac{\text{target HQ} \cdot BW \cdot AT_n}{CF_1 \cdot EF \cdot ED \cdot \left(\frac{IR_{sw}}{RfD_{ingest}} + \frac{CF_2 \cdot EV \cdot SA_w \cdot K_p \frac{t_{event}}{1+B} + 2 \cdot \tau \left(\frac{1+3B+3B^2}{(1+B)^2} \right)}{RfD_{dermal}} + \frac{VF \cdot IR_h \cdot ET}{RfD_{inhal}} \right)}$$

(for cranberry workers, organic compounds)

$$HBC_{sw} = \frac{\text{target HQ} \cdot \text{RfD}_{ingest} \cdot \text{BW} \cdot \text{AT}_n}{\text{BAF} \cdot \text{IR}_f \cdot \text{FI} \cdot \text{CF}_3 \cdot \text{EF} \cdot \text{ED} \cdot \text{CF}_1}$$

(for fish eaters)

As a screening tool, this approach uses conservative risk and hazard equations and exposure factors. The results should be viewed in the following manner:

- If the concentrations of chemical constituents in surface water are less than the calculated RBC or HBC, it is appropriate to report that there is no imminent risk associated with the detected chemicals.
- If the concentrations of chemical constituents in surface water are greater than the calculated RBC or HBC, it does not mean there is a definitive risk to human health. It does mean that these compounds need to be evaluated further using more realistic maximum exposure scenarios or a more sophisticated approach that reflects site-specific uses (i.e., exposure) and specific modes of uptake associated with the compounds of concern. If further evaluation is warranted, it would be conducted by either AFCEE or the Commonwealth of Massachusetts, specifically DEP or the Department of Public Health. Any further evaluations conducted by AFCEE would be done with the support of EPA and DEP.

1.2 RESULTS OF SCREENING-LEVEL HUMAN HEALTH RISK EVALUATION

Chemical concentrations detected in surface water were compared to RBCs and HBCs developed for each compound (Tables C-3, C-4 and C-5). EDB concentrations detected in surface water did not exceed the RBC or HBC.

Table C-1
Exposure Factors for Calculating Human Health
Risk-Based Surface Water Concentrations at the Quashnet River and Bogs

Constant	Definition	Units	RME Cranberry Worker	RME Adult Wader	RME Child Wader	RME Fish Eater
AT_c	Averaging time (cancer)	Days	25550	25550	25550	25550
AT_n	Averaging time (noncancer)	Days	9125	8760	2190	10950
B	Ratio measuring the permeability of the stratum corneum relative to the epidermis	None	Chemical-specific			NA
BAF	Bioaccumulation factor	L/kg	NA	NA	NA	Chemical-specific
BW	Body weight	kg	70	70	15	70
CF_1	Conversion factor	mg/µg	0.001	0.001	0.001	0.001
CF_2	Conversion factor	L/cm^3	0.001	0.001	0.001	NA
CF_3	Conversion factor	kg/g	NA	NA	NA	0.001
ED	Exposure duration	Years	25	24	6	30
EF	Exposure frequency	Days/year	16.8	104	104	350
ET	Exposure time	hr/day	8	1	1	NA
EV	Event frequency	$(day)^{-1}$	1	1	1	NA
FI	Fraction ingested	None	NA	NA	NA	1
HBC_{sw}	Hazard-based concentration, surface water	µg/L	Calculated	Calculated	Calculated	Calculated
IR_f	Ingestion rate, fish	G/day	NA	NA	NA	26
IR_h	Inhalation rate, hourly	M^3/hr	3.3	1.6	1.2	NA
IR_{sw}	Ingestion rate, surface water	L/day	0.05	0.05	0.05	NA
K_p	Dermal permeability constant	cm/hr	Chemical-specific			NA

Table C-1 (continued)
Exposure Factors for Calculating Human Health
Risk-Based Surface Water Concentrations at the Quashnet River and Bogs

Constant	Definition	Units	RME Cranberry Worker	RME Adult Wader	RME Child Wader	RME Fish Eater
RBC_{sw}	Risk-based concentration, surface water	µg/L	Calculated	Calculated	Calculated	Calculated
RfD_{dermal}	Dermal noncancer reference dose	mg/kg-day	Chemical-specific			NA
RfD_{ingest}	Oral noncancer reference dose	mg/kg-day	Chemical-specific			
RfD_{inhal}	Inhalation noncancer reference dose	mg/kg-day	Chemical-specific			NA
SA_w	Skin surface area, wading	cm^2	6600	6600	3400	NA
SF_{dermal}	Dermal cancer slope factor	$(mg/kg\text{-}day)^{-1}$	Chemical-specific			NA
SF_{ingest}	Oral cancer slope factor	$(mg/kg\text{-}day)^{-1}$	Chemical-specific			
SF_{inhal}	Inhalation cancer slope factor	$(mg/kg\text{-}day)^{-1}$	Chemical-specific			NA
t_{event}	Exposure duration	Hours	8	1	1	NA
VF	Volatilization factor	L/m^3	Chemical-specific			NA
τ	lag time	Hours	Chemical-specific			NA

Note: For FS-28 RME, EF = 12 days. For FS-1 RME, EF = 16.8 days
cm/hr = centimeters per hour
cm^2 = square centimeters
days/year = days per year
g/day = grams per day
hr/day = hours per day
kg = kilogram
kg/g = kilograms per gram
L/cm^3 = liters per cubic centimeter
L/day = liters per day
L/kg = liters per kilogram
L/m^3 = liters per cubic meter
m^3/hr = cubic meters per hour
mg/kg-day = milligrams per kilogram per day
mg/µg = milligrams per micrograms
NA = not applicable
RME = reasonable maximum exposure
µg/L = micrograms per liter

Table C-2
Chemical-Specific Data for Calculating Human Health
Risk-Based Surface Water Concentrations at the Quashnet River and Bogs

Compound	BAF[a] (reference)	VF	τ	B	Dermal Permeability Constant	Reference Doses (RfD) (mg/kg-day)			Cancer Slope Factors (mg/kg-day)-1		
					(cm/hr)	Dermal	Oral	Inhalation	Dermal	Oral	Inhalation
EDB	10 [(b)]	0.2	1.188	0.0091	0.003	NA	NA	5.70E-05	8.50E+01	8.50E+01	7.70E-01

References:

[(a)] from EPA Region IV, 1996, *Toxic Substance Spreadsheet*, EPA IV, Atlanta, GA.

[(b)] Log (BAF)<1 from AFCEE, 1998, *Draft Final Ethylene Dibromide Derivation of Aquatic Screening Benchmark*s. Prepared by S. Talmadge, Life Science Division, Oak Ridge National Laboratory, Oak Ridge, TN.

B = dimensionless ratio measuring the permeability of the stratum corneum relative to the epidermis
BAF = bioaccumulation factor (L/kg)
cm/hr = centimeters per hour
L/kg = liters per kilogram
L/m^3 = liters per cubic meter
mg/kg-day = milligrams per kilogram per day
NA = not applicable
VF = volatilization factor (L/m^3)
τ = lag time (hour)

Table C-3
Hazard-Based (HQ=10) Concentrations in Surface Water for EDB (µg/L) at FS-1

Compound	Cranberry Worker	Adult Wader	Child Wader	Adult Fish Eater	Integrated Receptor[a]
EDB	1.65E+02	4.36E+02	1.25E+02	NA	6.10E+01

Notes:
[a] The integrated receptor is the calculated summed exposures of the child wader, adult wader, adult fish eater, and cranberry worker.
Ingestion, dermal absorption, and inhalation exposure routes included
RME exposure scenario is used; 16.8 days of worker exposure at FS-1 per year.
EDB = ethylene dibromide
HQ = hazard quotient
NA = not applicable
RME = reasonable maximum exposure
µg/L = micrograms per liter

Table C-4
Risk Equivalent Concentrations (1×10^{-3}) in Surface Water for EDB (µg/L) at FS-1

Cranberry Worker	Adult Wader	Child Wading	Adult Fish Eater	Integrated Receptor[a]
170.0	80.0	90.0	8.0	6.5

Notes:
[a] The integrated receptor is the calculated summed exposures of the child wader, adult wader, adult fish eater, and cranberry worker.
Ingestion, dermal absorption, and inhalation exposure routes included
RME exposure scenario is used; 16.8 days of worker exposure at FS-1 per year.
EDB = ethylene dibromide
RME = reasonable maximum exposure
µg/L = micrograms per liter

Table C-5
Comparison of Surface Water and Treatment System Effluent Chemical Concentrations to Risk- and Hazard-Based Concentrations, Quashnet River and Bogs
May 2001 – April 2002

Location	Analyte	Cumulative Risk-Based Concentration (RBC)* at Target Risk of 1 x 10^{-3}	Cumulative Hazard-Based Concentration (HBC)* at Target Hazard of 10.0	Minimum Detect		Maximum Detect	
				All units µg/L			
Quashnet River and Bogs	1,2-DIBROMOETHANE (EDB)	6.5 E+00	6.1 E+01	0.043		0.190	

Data Sources: Jacobs, November 2001, Site Environmental Evaluation (SEE) database and AFCEE, 08 January and 13 September 2002, MMR-AFCEE Data Warehouse.

µg/L = micrograms per liter
* The listed RBCs and HBCs consider the combined exposure of child waders, adult waders, cranberry workers, and fish ingestion.

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